PORTLAND HARBOR SUPERFUND SITE:
PROPOSED ECOLOGICAL RISK ASSESSMENT DECISION FRAMEWORK

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This document is currently under review by US EPA and its federal, state, and tribal partners, and is subject to change in whole or in part.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

AOPC	area of potential concern
AWQC	ambient water quality criteria
BSAF	biota-sediment accumulation factor
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	chemical of concern
COPC	chemicals of potential concern
DEQ	Department of Environmental Quality
EPA	US Environmental Protection Agency
ERA	ecological risk assessment
FS	feasibility study
FWM	food web model
HHRA	human health risk assessment
LOE	line of evidence
LWG	Lower Willamette Group
PRG	preliminary remediation goal
RBCT	risk-based concentration threshold
RI/FS	remedial investigation/feasibility study
SMA	sediment management area
SQV	sediment quality value
TRV	toxicity reference value
TZW	transition zone water
WOE	weight of evidence

1.0 INTRODUCTION

This technical memorandum outlines the framework for integrating multiple lines of evidence (LOEs) in the ecological risk assessment (ERA) component of the Portland Harbor Remedial Investigation/Feasibility Study (RI/FS). The document was prepared by the Lower Willamette Group (LWG) and is intended to provide an overview of the processes for evaluating ecological risks from hazardous substances for the Portland Harbor Superfund Site (the Site), for identifying the chemicals that represent ecologically significant risk and locations where ecologically significant risks are encountered, and, most importantly, for incorporating the results of the risk assessment in the feasibility study (FS) to help identify candidate remedial actions.

This memorandum was prepared to address the following questions that have been raised recently in discussions with the US Environmental Protection Agency (EPA) and its partners regarding the ERA process for the Site:

1. What models and general assumptions will the LWG and EPA use in the ERA?
2. How will LWG and EPA use the various LOEs in the ERA to determine Site-wide ecologically significant risk?
3. How will LWG and EPA use the various LOEs in the ERA to determine area-specific (smaller scale) ecologically significant ecological risk?
4. How will LWG and EPA prioritize or weigh the various LOEs in the ERA?
5. How will LWG and EPA integrate information from various receptors and chemicals of concern (COCs) to identify final areas of potential concern (AOPCs) for consideration in the FS?
6. How will LWG and EPA use the results of the ERA in the FS?

The overall framework for the ERA has been presented in prior planning documents, including:

- Portland Harbor RI/FS scoping document (SEA 2002)
- Round 1 Work Plan (SEA et al. 2002)
- Appendix B (ERA Approach) of the *Portland Harbor Remedial Investigation/Feasibility Study Programmatic Work Plan* (Integral et al. 2004), hereafter referred to as the Programmatic Work Plan
- *Portland Harbor Superfund Site Ecological Risk Assessment: Comprehensive Synopsis of Approaches and Methods.* (Windward 2004), hereafter referred to as the ERA Comprehensive Synopsis of Approaches and Methods

Detailed technical approaches and results of preliminary analyses for several key ecological receptors and LOEs have also been presented in technical memoranda and reports, including:

- *Portland Harbor RI/FS Ecological Preliminary Risk Evaluation*, (Windward 2005a), including *Appendix A: Approach for the Preliminary Risk Evaluation for Ecological Receptors* and *Appendix B: Toxicity Reference Value Selection*
- *Estimating Risks to Benthic Organisms Using Sediment Toxicity Tests* (Windward 2005b)
- *Portland Harbor Superfund Site Ecological Risk Assessment: Interpretive Report: Estimating Risks to Benthic Organisms Using Predictive Models Based on Sediment Toxicity Tests* (Windward, in progress)

Because the overall ERA approach has been described previously, it will not be discussed in detail here. This memorandum focuses on the key models used in evaluating LOEs and developing sediment risk-based concentration thresholds (RBCTs); on the risk characterization steps for integrating LOEs and identifying AOPCs, receptors of concern, and COCs; and on the use of the ERA results in the FS.

The remainder of this document is organized as follows:

- Section 2 presents the status of the risk assessment process and identifies the relationship between risk evaluations conducted to date and remaining analyses and characterizations.
- Section 3 presents a list of the models and assumptions that will be used in the ERA and FS to address the six questions identified above.
- Section 4 presents the framework for decision-making, as well as the LOEs and kinds of site-specific data that will be used to estimate ecological risks.
- Section 5 details how the products of the ERA will be used to inform the FS and the risk management process.
- Section 6 lists the references cited in this document.

2.0 RISK ASSESSMENT PROCESS OVERVIEW

Figure 1 presents the risk characterization process, including how the various rounds of data for the Site are incorporated into the assessment process and the specific steps that will be used to identify ecological COCs and AOPCs which will be use in the FS to identify SMAs and evaluate remedial action alternatives. Along with the results of the human health risk assessment (HHRA) and consideration of sediment properties, habitat, and other factors, the final products of the baseline ERA will provide the ecological basis as input in developing sediment management areas (SMAs) and preliminary remediation goals (PRGs) in the FS. The approach to the ERA described in this memorandum is consistent with EPA guidance (EPA 1997; 1998) and approaches used to characterize risks at major Superfund sites.

The risk evaluation process is iterative, with each step supporting the next. As shown in Figure 1, the LWG has completed a preliminary risk analysis for several receptors in the *Portland Harbor RI/FS Ecological Preliminary Risk Evaluation* (Windward 2005a). The *Preliminary Risk Evaluation* (PRE) presented the results of a preliminary screening-level assessment that was based on maximum concentrations from Round 1 tissue data and Rounds 1 and 2 surface sediment data. Results of this preliminary screen were used primarily to identify additional data needs for assessing risk to wildlife. This analysis will be updated with both new data (additional Round 2 data) and an analysis of the remaining receptors will be conducted in the *Portland Harbor RI/FS Comprehensive Round 2 Site Characterization Summary and Data Gap Analysis Report*, hereafter referred to as the Comprehensive Round 2 Report.

The Comprehensive Round 2 Report will include an updated problem formulation, including an updated and expanded screening step to identify chemicals of potential concern (COPCs) and receptors on which the baseline ERA will focus. The screening step will be conducted in accordance with EPA guidance (EPA 1997).

The baseline ERA, which will be included with the RI/FS report, will provide the completed analysis and risk characterization and will be based on the complete database of Round 1, 2, and 3 data. COC and receptor pairs for which ecologically significant risk is expected will be identified in the baseline ERA. Spatial scales and habitat availability will be considered as part of baseline risk characterization, especially in determining the ecological significance of estimated risks. As part of the risk characterization phase, AOPCs and RBCTs will be developed for the COCs identified in the baseline ERA.

3.0 MODELS AND ASSUMPTIONS

Because it is not possible or practicable to directly measure all aspects of exposure and toxicity, it is a generally accepted practice to use models in various stages of the risk assessment and risk management process. The baseline ERA will use a combination of empirical measurements and modeled data to provide a comprehensive evaluation of the multiple receptors and pathways. In various stages of the ERA, models will be used to estimate exposures and to develop RBCTs that can be used to characterize risk over a variety of spatial scales and identify AOPCs to support FS analyses.

Empirical approaches, such as conducting sediment toxicity tests and tissue-residue analyses, will be relied upon to characterize risk and identify COCs that contribute to risk within the Site. These empirical data will be augmented by the use of models to either further characterize risks or develop RBCTs for a given receptor and chemical. RBCTs will be determined only for receptor/COC pairs identified in the risk characterization process. In characterizing risks, empirical data will take precedence over model predictions when data are available (e.g., measured toxicity data over predicted toxicity).

Spatial scales of resolution used for modeling will be appropriate to the life history, distribution, and behavior of the receptors being modeled. For the purposes of this document, Site-wide spatial scale refers to the entire Study Area Site; area-specific spatial scale refers to a relevant home range or foraging range that encompasses an area smaller than the Site; and location-specific scale refers to point-specific exposures, based on single stations associated with sediment chemistry data. Applying models over the various spatial scales allows use of sediment chemistry and habitat data from specific areas or locations where biological response data and tissue residue data are not available to address special concerns of EPA and its partners. To ensure an appropriate level or protection for ecological receptors, models used in the baseline ERA will be developed using input values and assumptions that represent plausible conservative as well as realistic cases. Sensitivity analysis and uncertainty analysis will also be used to evaluate the models and ensure environmental protectiveness.

The following is a list of the models to be used in the baseline ERA for the Site:

- **Benthic predictive model** – A model that links toxicological endpoints in benthic invertebrates to COPC concentrations in sediment will be used to develop RBCTs for sediment (i.e., [sediment quality values] SQVs). These RBCTs will then be applied to interpret sediment chemistry data to characterize risks for areas where sediment toxicity was not measured directly. The guiding assumptions are that there is a relationship between toxicity and sediment chemistry, which the benthic predictive model adequately characterizes, and that SQVs developed from this relationship can be applied at a variety of spatial scales (i.e., Site-wide or area-specific) to predict whether or not sediments

are toxic to benthic invertebrates. Conservative assumptions have been incorporated into the development of SQVs through the hit/no hit definition and the selected low "false negative" rate on which the SQV derivation was based.

- **Food web model** – A food web model (FWM) will be used to determine RBCTs for selected bioaccumulative COCs based on the protection of birds, mammals, and fish. Essentially, the FWM is used to translate acceptable tissue concentrations of COCs in wildlife or their prey to RBCTs that represent protective sediment concentrations. The guiding assumption is that there is predictable relationship between COC concentrations in abiotic media and biological tissue. The RBCTs can be applied to interpret area-weighted sediment concentrations of COPCs either Site-wide or on an area-specific basis depending on the spatial scale appropriate to a specific receptor. The RBCTs for wide-ranging receptors will be used to assess risk over scales relevant to the receptor home range and habitat requirements. Ecological protectiveness of the RBCTs will be ensured by adopting conservative assumptions in the application of the FMW.
- **Biota-sediment accumulation factor model** – A biota-sediment accumulation factor (BSAF) will be used in exposure and risk models to characterize risk and to determine RBCTs for non-bioaccumulative chemicals (both Site-wide and area-specific). The BSAF will be used for non-bioaccumulative chemicals because the FWM is not appropriate for such chemicals (e.g., for metals). The BSAF will be derived for sculpin and benthic invertebrates based on field and laboratory data. The guiding assumption is there are quantitative relationships between co-located sediment chemical concentrations and chemical concentrations in tissue and that the site-derived BSAFs adequately characterize those relationships. The sediment RBCTs will then be applied to interpret sediment chemistry data to characterize risk where tissue residues were not measured directly. Ecologically protective RBCTs will be ensured by BSAFs that minimize the chance of underestimating bioaccumulation.
- **Wildlife exposure models** – Wildlife exposure models will be used to estimate dietary exposure (as a daily dietary dose) for specific bird and mammal receptors using receptor-specific parameters, including body weight, ingestion rates for food and sediment, dietary portions of prey items, home range size, and site use factors. Exposure models will incorporate a range of parameters intended to ensure that risk to wildlife is not underestimated. For piscivorous birds, tissue burden in eggs will

also be estimated using relationships reported in the literature for predicting the COPC concentration in egg tissues from estimates of dietary doses. These exposure models will be used to characterize risks to wildlife receptors. The wildlife exposure models will also be used to calculate acceptable COC concentrations in prey tissue, and the BSAF model or FWM will then be used to develop sediment RBCTs for wildlife corresponding to acceptable concentrations in prey tissue.

During the FS, RBCTs from the ERA will be considered along with other factors (i.e., background, HHRA results, feasibility of remedial actions, habitat type, sediment properties) to develop sediment remediation goals for the Site, or for areas at a smaller scale.

4.0 RISK CHARACTERIZATION FRAMEWORK

This section presents the framework for how LOEs will be integrated in the risk characterization phase of the baseline ERA to develop risk estimates and inform risk management evaluations in the FS. The LOEs and the site-specific data that have been collected to support each LOE are summarized in Table 1.

4.1 OBJECTIVES OF THE RISK CHARACTERIZATION

The objectives of the risk characterization phase of the ERA are to:

- Estimate risks to ecological receptors by integrating information from the exposure and effects analyses (i.e., various LOEs) and determine the ecological significance of risks.
- Define receptors of concern, which are those receptors for which an ecologically significant risk is present at the Site.
- Identify ecological COCs, which are those COPCs present at the Site at concentrations and spatial scales considered to be ecologically significant.
- Define Site-wide and localized areas of ecologically significant risk.
- Define AOPCs and characterize the magnitude of risk in individual AOPCs for relevant receptor/COC pairs.
- Delineate AOPCs in a series of maps or overlays to be used to develop SMAs in the FS.
- Identify and summarize the uncertainties, assumptions, and qualifiers in the risk assessment.

4.2 LINES OF EVIDENCE

The specific LOEs that were selected for each assessment endpoint that are included in the Portland Harbor ERA and the data that support these LOEs are presented in Table 1. In the absence of any significant changes to the ecological conceptual site model based on evaluations of new data, the LOEs should not change. This LOE approach is consistent with EPA guidance (EPA 1997, 1998). Following EPA guidance (EPA 1997, 1998), various factors, such as ecological relevance, exposure relevance, and how directly an LOE is related to an assessment endpoint, were considered in selecting the LOEs. These factors are considered when determining how the various LOEs will be weighted and prioritized for characterizing risks and identifying AOPCs for each receptor group.

Primary LOEs are based on the ecotoxicological measurements or analyses that best represent the exposure pathways and/or effects of greatest interest and are associated with the lowest uncertainty regarding interpretation of effects. Primary LOEs are direct

measures of toxicity or bioaccumulation or rely on standardized methods for characterizing risk based on comparison of estimated exposure to toxicity reference values (TRVs). It is anticipated that sediment RBCTs will be developed based on the primary LOEs for:

- Benthic invertebrates
- Fish
- Wildlife (i.e., birds and mammals)

Secondary LOEs represent endpoints that have less direct relevance to the assessment endpoints or have substantially higher uncertainty. Secondary LOEs will be used to help characterize risk, but will not be used to develop sediment RBCTs. Secondary LOEs can help characterize uncertainty regarding the conclusions based on the primary LOEs. In addition, secondary LOEs may be used to identify sources of exposure other than sediment that can significantly contribute to risk (i.e., surface water, transition zone water [TZW]), or are indication of other sublethal effects not directly relevant to assessment endpoint characteristics.

Figures 2 through 9 present the risk assessment framework for benthic invertebrates, fish, amphibians, and wildlife. The figures show how each LOE is used to: 1) determine which receptor/COPC pairs result in ecologically significant risk; and 2) define AOPCs associated with ecologically significant risks.

4.3 DEFINING A WEIGHT-OF-EVIDENCE APPROACH FOR INTEGRATING MULTIPLE LOES

The LWG is proposing to use a qualitative weight of evidence (WOE) approach to integrate LOEs that was developed by the Massachusetts Weight-of-Evidence Workgroup, a group of ecological risk assessors from both government and private sectors (Menzie et al. 1996). This WOE approach weights each LOE, determines the magnitude of the response observed in measurement endpoints for each LOE, and makes conclusions regarding the concurrence among LOEs. The end goal of the WOE is to determine whether there is a significant risk of harm to the environment. This qualitative approach or a similar process has been used for Superfund ERAs at major sites, including PCB sites such as the Hudson River ERA in New York and the Housatonic ERA in Massachusetts.

The Massachusetts WOE approach will be applied to LOEs for each receptor group (e.g., benthos) or receptor guild (e.g., piscivorous fish) separately using the relative weights for LOEs shown in Table 1. After developing an integrated risk estimate for each receptor group, overall risks of the Site will be characterized by overlaying maps of AOPCs for each COC/receptor pair to use in the FS.

4.4 SPATIAL SCALE

Risk to ecological receptors should be based on scales that are ecologically relevant (e.g., are consistent with habitat preference, mobility, and home range). Spatial scales for some receptors encompass the entire Site, while other receptors exhibit home ranges that encompass areas smaller than the Site.

For receptors that occupy relatively small home ranges such as benthic invertebrates and sculpin, risk assessment and risk management is ultimately limited by the density of sediment sampling locations in areas of concern, and the uncertainty of extrapolating concentrations between sampling locations. For receptors with home ranges that may include large portions of the Site (or may be larger than the Site), adequately conservative risk assessment depends on the extent to which COPC concentrations (and exposure) are represented for areas of potential contamination. For both small- and large-scale receptors, the existing sediment data set will result in conservative risk estimates, because sampling is biased to areas of known or suspected contamination. It is unlikely that risk will be underestimated because EPA and its partners have identified all significant sources of contamination. The range of relevant spatial scales will be incorporated into the risk assessment and in defining AOPCs for ecological receptors by aggregating data over scales that are appropriate for each of the representative receptor.

The following is a brief synopsis of how relevant spatial scales will be defined for various receptors.

- **Benthic invertebrates** – Location-specific spatial scales will be evaluated for benthos using existing point-location data (i.e., measured toxicity responses, predicted toxicity in surface sediment, and measured tissue residues of COPCs). The scale of risk to benthic invertebrates will be assessed by mapping toxicity responses and exceedances of sediment RBCTs.
- **Sculpin** – Compared to other fish receptors, sculpin have a relatively small home range. Therefore, area-specific spatial scales will be used to estimate risk (i.e., measured tissue residues and predicted tissue concentrations of COPCs). In part, AOPCs will be identified based on tissue concentrations of COPCs that exceed risk thresholds in those areas where sculpin were collected. In areas where sculpin tissue was not collected, but where the habitat indicates sculpin may utilize the area, AOPCs will be identified based on estimated tissue concentrations of COPCs (using a BSAF) that exceed risk thresholds. Data used in the assessment will be based on exposure areas (based on relevant habitat) identified in the ERA Comprehensive Synopsis of Approaches and Methods.
- **Smallmouth bass** – Smallmouth bass have home ranges that are considerably larger than those of sculpin but smaller than those

of some other fish species (i.e., less than Site-wide). Therefore, area-specific spatial scales will be used to characterize risk. AOPCs will be identified based on tissue COPC concentrations that exceed risk thresholds in those areas where smallmouth bass were collected. AOPCs will also be identified based on estimated tissue concentrations of COPCs (using a BSAF or FWM) that exceed risk thresholds in areas of likely bass habitat, but where smallmouth bass tissue was not collected. AOPCs will be identified based on estimated tissue concentrations of COPCs (using a BSAF) that exceed risk thresholds. Data used in the assessment will be based on exposure areas identified in the ERA Comprehensive Synopsis of Approaches and Methods.

- **Other fish receptors** – For fish receptors other than sculpin and smallmouth bass, risk will be evaluated using a Site-wide spatial scale, because the home ranges of these fish receptors exceed the area of the Site. While risks will be evaluated on a Site-wide basis, the effectiveness of remedies evaluated in the FS will need to address the contribution of individual SMA remediation to achieving the Site-wide goal for fish receptors (i.e., relative effect that reducing the area weighted average sediment concentration is expected to have on fish tissue concentrations).
- **Sandpiper** – While sandpiper have a home range that encompasses the Site, they forage in limited portions of the Site. Therefore, area-specific spatial scales will be evaluated in the ERA based on foraging areas that have already been identified and sampled for the sandpiper. AOPCs will be identified for sandpiper based on risks associated with data from each of these foraging areas. Data used in the assessment will be based on exposure areas identified in the ERA Comprehensive Synopsis of Approaches and Methods. RBCTs will be identified based on a back-calculation for COCs (for which ecologically significant risks are expected). A forward-mode risk assessment will be conducted for the ERA, so RBCTs will not be necessary to define baseline risks for the sandpiper. However, RBCTs will be applied in the FS if ecologically significant risks are expected based on the baseline ERA.
- **Other wildlife receptors** – The Site-wide spatial scale will be evaluated for species such as the river otter and raptors for which the home range exceeds the area of the Site. Data used in the assessment will be based on exposure areas identified in the ERA Comprehensive Synopsis of Approaches and Methods. As with the sandpiper, a forward-mode risk assessment will be conducted for the ERA, so RBCTs will not be necessary to define baseline risks for the sandpiper. However, RBCTs will be applied in the

FS if ecologically significant risks are expected based on the baseline ERA.

- **Aquatic plants and amphibians** – Risk will be evaluated for quiescent habitat areas. These areas were identified in the field sampling plans and in the ERA Comprehensive Synopsis of Approaches and Methods.

The determination of ecologically significant risk for any of the above receptors will be a risk management determination based on the area of risk threshold exceedances, the magnitude of the exceedance, the habitat quality, and other factors considered in the FS.

4.5 AOPC DEFINITION

As noted above, the WOE approach will be used to define AOPCs for each receptor group or guild. RBCTs, estimated on primary LOEs, will be calculated for each COC. These RBCTs will provide a means to map areas of ecologically significant risk at a variety of scales down to the resolution provided by the bulk sediment chemistry sampling locations. The spatial scale of resolution used will be appropriate for the receptor of concern. Empirical information for a primary LOE will always take precedence over modeled RBCTs for defining. For example, if the benthic predictive model predicts no toxicity for a particular area based on sediment chemical concentrations, but actual bioassay results in this area indicate toxicity, the final assessment will be based on the bioassay results. Similarly, tissue data that indicate toxicity (i.e., tissue concentrations exceed TRVs) would take precedence over risk estimates based on RBCTs derived from the FWM or BSAF models. In each case, the converse is also true. For example, tissue data indicating no risk would take precedence over risk estimates based on RBCTs derived from the models.

Supporting LOEs may also be used to identify some or all of an AOPC when they provide sufficient evidence of toxicity as discussed above. These AOPCs (or portions of AOPCs) will be resolvable down to the scale of the information available for those supporting LOEs.

The above approach of using primary empirical LOEs, sediment RBCTs, and empirical evidence from supporting LOEs is applicable to benthic invertebrates, fish, and wildlife. Far less reliable toxicological data are available for amphibians, reptiles, and aquatic plants. Therefore, preliminary risk evaluations will be conducted using ambient water quality criteria (AWQC) for amphibian and reptiles in previously identified habitat. For aquatic plants, preliminary risk evaluations will be conducted using water and soil/sediment based toxicological benchmarks from the literature. Areas identified using the above process that are not identified as AOPCs based on other receptors will be mapped and provide the basis for discussion of whether separate AOPCs should be established.

4.6 RISK-BASED CONCENTRATION THRESHOLDS

RBCTs for sediment are derived in an ERA for several reasons. First, they may be used in the risk characterization stage to interpret sediment chemistry data when the spatial resolution and/or coverage of sediment chemistry data are greater than those of the data for tissue chemistry or biological response endpoints. Essentially, these RBCTs are used to characterize risk in areas where sediment chemistry data are available, but where tissue residues or biological endpoints are not. Second, RBCTs may be used to develop remediation goals, which will be used in the FS process, along with other criteria, to identify cleanup areas. RBCTs may also be used during the FS to assess the residual risk associated with different remedial alternatives. Finally, in future monitoring programs, RBCTs or PRGs may be used to interpret sediment chemistry data that are collected to verify cleanup, assess recontamination, track natural recovery of sediments, or evaluate the continuing long-term effectiveness of the remedy.

Sediment RBCTs will be developed based on the primary LOEs for:

- Benthic invertebrates
- Fish
- Wildlife (i.e., birds and mammals)

Multiple sets of RBCTs may be defined for each receptor group because RBCTs are derived for a single species and these receptor groups may include multiple species.

RBCTs for benthic invertebrates can also be applied at any smaller spatial scale, including individual sediment sampling stations. For fish and wildlife, RBCTs will not be applied to single locations because these receptors move in the environment and occupy a home range that is substantially larger than the area represented by a single sediment chemistry station. Therefore, when RBCTs are used to delineate AOPCs for fish and wildlife, they will be applied to aggregated sediment data within an area greater than or equal to the home range of the receptor for which the RBCT was derived (or possibly the average, minimum, or maximum home range size for the receptor group in a sensitivity analysis).

4.7 PRODUCTS OF THE ERA

The risk characterization phase of the ERA consists of a risk estimation step in which LOEs will be assessed using the WOE approach discussed above to estimate risks for each receptor/COPC pair. The ecological significance of those estimated risks is determined by considering factors such as the magnitude of effects, the spatial extent of exceedances of risk thresholds, and recovery potential (EPA 1992). Based on the risk estimates, a consideration of ecological significance, and an uncertainty analysis, final AOPC and COCs are developed. The products of the risk characterization will accomplish the following:

- Identify COCs as those chemicals that represent ecologically significant risks to ecological receptors on a Site-wide or localized basis.

- Identify receptors for which risks are significant Site-wide or in localized areas.
- Delineate localized AOPCs and map the relative magnitude of risk in individual AOPCs for each receptor/COC pair in a series of maps.
- Overlay AOPC maps of receptor/COC pairs for the FS. This product will be used to develop SMAs in the FS.
- Derive sediment RBCTs for selected receptor/chemical pairs.

5.0 USE OF ERA PRODUCTS IN FEASIBILITY STUDY

The AOPC maps developed for the ERA illustrate areas of ecologically significant risk for each receptor and will be used in the FS to help define SMAs. In addition to ERA results, SMA development will also take into account results from the HHRA, estimated background concentrations, estimated areas and volumes of sediments in SMAs, physical environments, habitat types, river uses, and potential ongoing sources.

5.1 RELATIONSHIP OF WATER AND SEDIMENT RISKS

As noted above and in Table 1, supporting LOEs will include the comparison of COPC concentrations in surface and TZW to water-based concentrations goals. For surface water, this information will be used to identify the potential need for source control in the FS. For TZW, this supporting LOE for benthic invertebrates could lead to FS discussions of potentially needed groundwater source controls as well as a definition of a sediment AOPC based on these exceedances. As with other supporting LOEs, if there is strong evidence of TZW risks based on this LOE, a sediment AOPC may be defined in whole or in part based on this information.

Sediment RBCTs derived from the FWM will account for the aggregate risk from both sediments in the water column (i.e., via sediment bed resuspension) or upstream surface water suspended sediment inputs and the in-place (bedded) sediments. The FWM will provide an indication of the proportion of risk attributable to direct sediment bed exposure versus water column exposure. Some portion of the water risk will also be attributable (indirectly through resuspension of sediments) to the sediment bed, but the FWM is incapable of identifying the proportion of risk from sediment resuspension versus upstream surface water. This correction, conducted outside the FWM, will help define RBCTs that truly represent the overall relationship between the sediment and the risks defined for the Site. The estimate of the contribution of water column chemicals from bed resuspension will be supplied by the fate and transport evaluation, which will be supported by Round 3 data from sediment traps and the surface water column samples as well as source data from Oregon Department of Environmental Quality (DEQ)-led programs.

5.2 CONVERSION FROM RBCTS TO PRGS

RBCTs developed in the ERA do not represent PRGs. PRGs will be developed at the start of the FS process and PRGs build upon RBCTs by overlaying other, additional factors that may be relevant to setting achievable goals for cleanup. These include, but are not limited to, the results of the HHRA, background information, site uses, physical/chemical characteristics of sediments, and habitats. Any of these factors may require the modification of an RBCT into a PRG that is most appropriate for the Site. For example, the RBCT may be set at 100 ppb for a chemical, but background information may indicate that general upstream watershed (i.e., non-Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA]) sources of this

chemical are 150 ppb. Thus, the PRG for this chemical would be set at 150 ppb (or the background concentration).

5.3 SMA DEFINITION

SMAs will incorporate AOPCs for ecological receptors, but will also be based on other factors, as noted above. For most area-specific AOPCs, one or two SMAs are likely to define the area of needed cleanup. However, it is expected that there will also be a Site-wide AOPC for one or more bioaccumulative chemicals that cause ecologically significant risk in fish or higher-trophic-level receptors. In these cases, it is expected that these Site-wide AOPCs will be split into several smaller functional SMAs that can be addressed in more "manageable" units for the FS. The basis for splitting these SMAs will be the other types of information noted in the Programmatic Work Plan and summarized above. In addition to the mapping of AOPCs and SMAs, an overall matrix will be used to summarize the applicable PRGs relevant to each SMA. For each SMA, the matrix would include each of the receptor groups that were found to be at risk within the SMA via the WOE approach, PRGs that are exceeded within the SMA, and the magnitude of these exceedances (e.g., hazard quotients). The FS would evaluate the PRGs that would be met and/or to what extent the magnitude of each PRG exceedance could be reduced by each remedial alternative to determine the effectiveness of the remedial alternatives.

Table 1. Summary of ecological lines of evidence

Receptor	Weight of Evidence[a]	Lines of Evidence for Supporting Risk Evaluation	LWG Samples Collected to Support LOE
Benthic Invertebrates			
Benthic community	high	Primary LOE: Sediment toxicity testing (direct toxicity and/or resulting area-specific SQVs developed using the predictive model).	233 samples of Round 2 surface sediment chemistry and co-located toxicity test data with *Chironomus tentans* (10-day) and *Hyalella azteca* (28-day) (sites approved by EPA).
	medium	Supporting LOE: Benthic tissue data compared to tissue-based TRVs.	27 samples of crayfish tissue and 3 samples of clam tissue collected during Round 1; 33 samples of Round 2 field-collected clam tissue, 33 samples of lab clam (*Corbicula fluminea*) and lab worm (*Lumbriculus variegatus*) bioaccumulation tests (sample locations approved by EPA).
	medium	Supporting LOE: Surface water data compared to AWQC or other screening levels.	3 rounds (and any additional rounds) of 23 Round 2 surface water chemistry samples (sample locations approved by EPA).
	medium	Supporting LOE: TZW data compared to AWQC or other screening levels.	Round 2 TZW chemistry from ecologically relevant areas (i.e., the upper 30 cm). Number of samples to be determined after completion of study.
Shellfish	high	Primary LOE: Shellfish tissue data compared to tissue-based TRVs.	27 samples of Round 1 crayfish tissue and 3 samples of clam tissue; 33 samples of Round 2 field-collected clam tissue, 33 samples of clam (*Corbicula fluminea*) laboratory bioaccumulation tests (sample locations approved by EPA).
	medium	Supporting LOE: Sediment toxicity testing.	233 samples of Round 2 surface sediment chemistry and co-located toxicity test data with *Chironomus tentans* (10-day) and *Hyalella azteca* (28-day) (sites selected and approved by EPA).

Table 1. Summary of ecological lines of evidence

Receptor	Weight of Evidence[a]	Lines of Evidence for Supporting Risk Evaluation	LWG Samples Collected to Support LOE
Fish			
Invertivorous fish (juvenile chinook salmon, peamouth, and sculpin)	high	Primary LOE: Non-metabolized, non-regulated chemicals; fish tissue data compared to tissue-based TRVs (sediment based risk concentrations developed using tissue-based TRVs and BSAFs or FWM).	36 samples of Round 1 sculpin, juvenile chinook, and peamouth whole-body tissue; 12 samples of Round 2 juvenile chinook salmon whole-body tissue.
	high	Primary LOE: Metabolized or physiologically regulated chemicals will be assessed using the dietary TRV approach; potential exposure through the diet will be estimated using representative prey items and incidental ingestion of sediment; the high uncertainty associated with this approach will be discussed and secondary LOEs will be considered (sediment based risk concentrations developed using tissue-based TRVs and BSAFs or FWM).	30 samples of Round 1 invertebrate tissue; 10 samples of Round 2 multiplate invertebrate tissue; 33 samples of Round 2 field and laboratory bioaccumulation invertebrate tissue; 4 samples of Round 2 juvenile chinook stomach content chemistry and 3 samples of stomach contents identification; 579 samples of Round 1 and 2 surface sediment chemistry (Site-wide).
	medium	Supporting LOE: Surface water data measuring direct toxicity effects of non-bioacummulative chemicals compared to AWQC or other screening levels for protection of early life stages.	3 rounds (and any additional rounds) of 23 Round 2 surface water chemistry samples (Site-wide).
	low	Additional qualitative information: Any existing observational information (e.g., existing skin condition or abnormalities) will be discussed in the baseline ERA.	Round 1 and 2 field observations.
Omnivorous/ herbivorous fish (largescale sucker and white sturgeon, carp as surrogate for PCBs and dioxin-like chemicals)	high	Primary LOE: Non-metabolized, non-regulated chemicals; fish tissue data compared to tissue-based TRVs (sediment based risk concentrations developed using tissue-based TRVs and BSAFs or FWM).	12 samples of Round 1 largescale sucker and carp whole-body tissue; proposed Round 3 white sturgeon whole-body tissue and/or modeling.
	high	Primary LOE: Metabolized or physiologically regulated chemicals will be assessed using the dietary TRV approach; potential exposure through the diet will be estimated using representative prey items and incidental ingestion of sediment; the high uncertainty associated with this approach will be discussed and secondary LOEs will be considered (sediment based risk concentrations developed using tissue-based TRVs and BSAFs or FWM).	30 samples of Round 1 invertebrate tissue; 33 samples of Round 2 field and lab bioaccumulation invertebrate tissue; 579 samples of Round 1 and 2 surface sediment chemistry (Site-wide).

Table 1. Summary of ecological lines of evidence

Receptor	Weight of Evidence[a]	Lines of Evidence for Supporting Risk Evaluation	LWG Samples Collected to Support LOE
	medium	Secondary LOE: Surface water data measuring direct toxicity effects of non-bioaccumulative chemicals compared to AWQC or other screening levels for protection of early life stages.	3 rounds (and any additional rounds) of 23 Round 2 surface water chemistry samples (Site-wide).
	low	Additional qualitative information: Any existing observational information (e.g., existing skin condition or abnormalities) will be discussed in the baseline ERA.	Round 1 field observations.
Piscivorous fish (smallmouth bass and northern pikeminnow)	high	Primary LOE: Non-metabolized, non-regulated chemicals; fish tissue data compared to tissue-based TRV (sediment based risk concentrations developed using tissue-based TRVs and FWM).	20 samples of Round 1 smallmouth bass and northern pikeminnow whole-body tissue.
	high	Primary LOE: Metabolized or physiologically regulated chemicals will be assessed using the dietary TRV approach; potential exposure through the diet will be estimated using representative prey items and incidental ingestion of sediment; the high uncertainty associated with this approach will be discussed and secondary LOEs will be considered (sediment based risk concentrations developed using tissue-based TRVs and BSAFs or FWM).	30 samples of Round 1 invertebrate tissue; 33 samples of Round 2 field and lab bioaccumulation invertebrate tissue; 579 samples of Round 1 and 2 surface sediment chemistry (Site-wide).
	medium	Secondary LOE: Surface water data measuring direct toxicity effects of non-bioacummulative chemicals compared to AWQC or other screening levels for protection of early life stages.	3 rounds of 23 Round 2 surface water chemistry samples (Site-wide).
Detritivorous fish (Pacific lamprey ammocoetes)	high	Primary LOE: Non-metabolized, non-regulated chemicals; fish tissue data compared to tissue-based TRV (sediment based risk concentrations developed using tissue-based TRVs and BSAFs or FWM).	9 lamprey ammocoetes collected during Round 2 benthic sledge sampling; possible additional sampling of lamprey ammocoete in Round 3.
	medium	Secondary LOE: Surface water data measuring direct toxicity effects of non-bioacummulative chemicals compared to AWQC or other screening levels for protection of early life stages.	3 rounds (and any additional rounds) of 23 Round 2 surface water chemistry samples (Site-wide).

Table 1. Summary of ecological lines of evidence

Receptor	Weight of Evidence[a]	Lines of Evidence for Supporting Risk Evaluation	LWG Samples Collected to Support LOE
Wildlife			
Invertivorous/ omnivorous birds (spotted sandpiper)	high	Primary LOE: Dietary TRV approach (potential exposure through diet).	30 samples of Round 1 invertebrate tissue; 10 samples of Round 2 multiplate invertebrate tissue; 33 samples of Round 2 field and lab bioaccumulation invertebrate tissue; 25 samples of Round 2 surface sediment collected from shorebird foraging areas.
Carnivorous/ omnivorous birds (hooded merganser)	high	Primary LOE: Dietary TRV approach (potential exposure through diet).	30 samples of Round 1 invertebrate and fish tissue; 10 samples of Round 2 multiplate invertebrate tissue; 33 samples of Round 2 field and lab bioaccumulation invertebrate tissue; 25 samples of Round 2 surface sediment collected from shorebird foraging areas; more than 320 samples of Round 1 and 2 surface sediment collected from relevant exposure areas (e.g., < 20 ft).
Piscivorous birds (bald eagle and osprey)	high	Primary LOE: Dietary TRV approach (potential exposure through diet).	80 samples of Round 1 fish tissue; more than 320 samples of Round 1 and 2 surface sediment collected from relevant exposure areas (e.g., < 20 ft).
	medium	Secondary LOE: Bird egg TRV modeling approach for a limited list of chemicals (i.e., dioxins, PCBs, DDE, and mercury).	80 samples of Round 1 fish tissue.
Piscivorous mammals (mink and river otter)	high	Primary LOE: Dietary TRV approach (potential exposure through diet).	30 samples of Round 1 invertebrate tissue and 80 samples of fish tissue; 33 samples of Round 2 field and lab bioaccumulation invertebrate tissue; More than 320 samples of Round 1 and 2 surface sediment collected from relevant exposure areas (e.g., < 20 ft).
Amphibians and Reptiles			
Amphibians	high	Primary LOE: Surface water data compared to AWQC or other literature-based screening levels to protect sensitive life stage.	3 rounds (and any additional rounds) of 14 Round 2 surface water chemistry samples collected from quiescent areas.
Plants			
Aquatic plants	high	Qualitative evaluation: A qualitative discussion of how surface water and/or surface sediment concentrations compare to relevant toxicity screening levels for emergent aquatic plant exposure.	3 rounds (and any additional rounds) of 14 Round 2 surface water chemistry samples and surface sediment from relevant exposure areas (e.g., quiescent areas for surface water).

a Weight of evidence refers to the qualitative weight that will be given to each LOE for determining risk conclusions for single receptor/assessment endpoint pair.

AWQC – ambient water quality criteria
EPA – US Environmental Protection Agency
LOE – line of evidence
SQV – sediment quality value
TRV – toxicity reference value
TZW – transition zone water

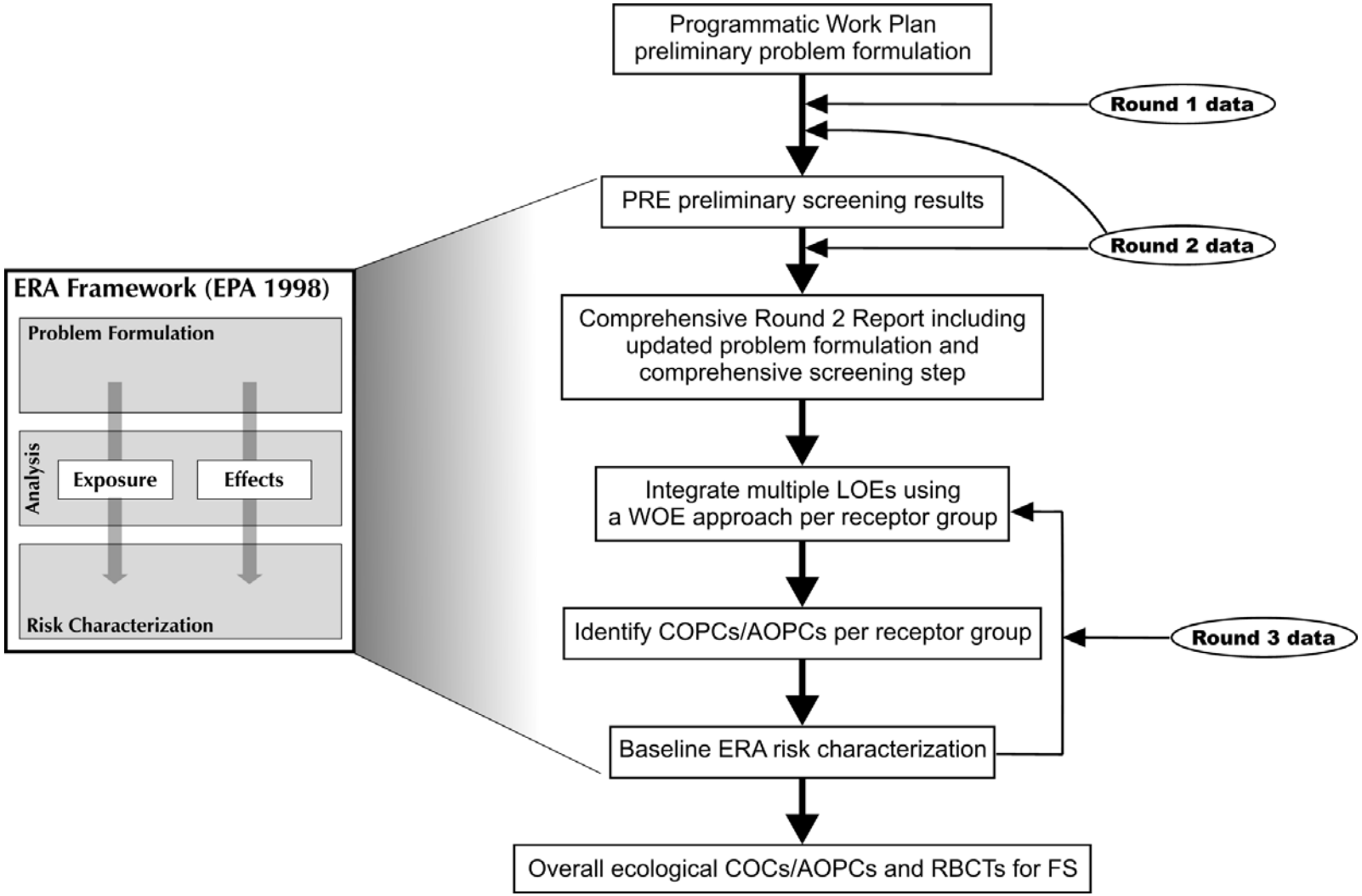

Figure 1. Portland Harbor Risk Characterization

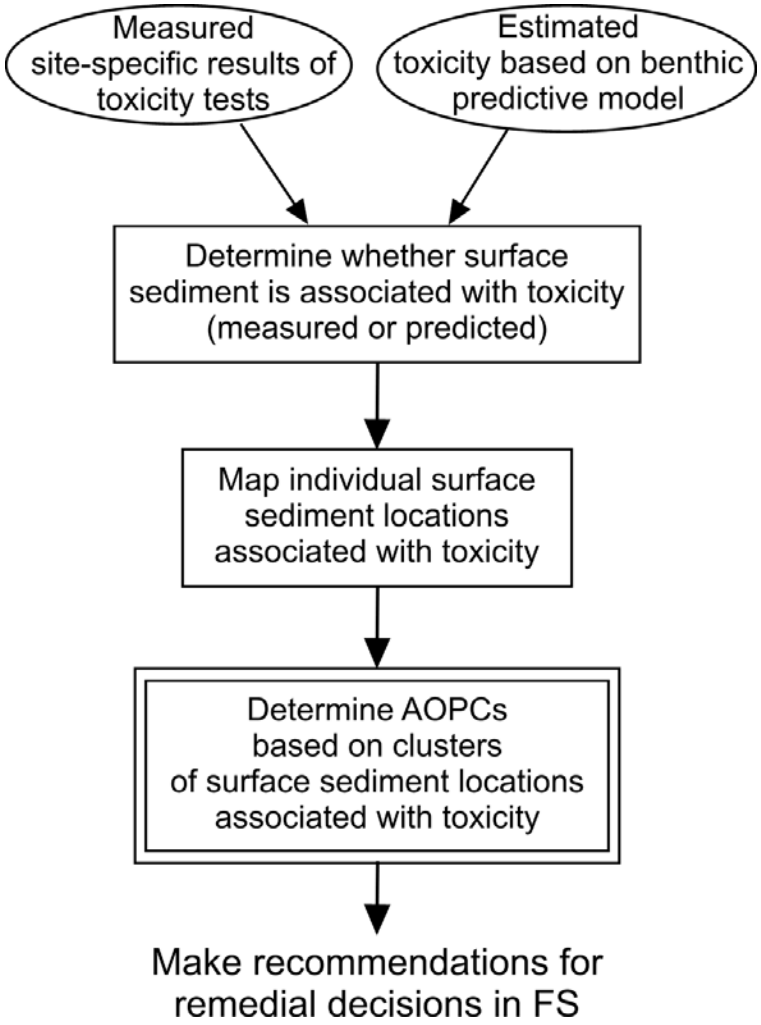

Figure 2. Risk Characterization framework for benthic invertebrates: direct toxicity LOE

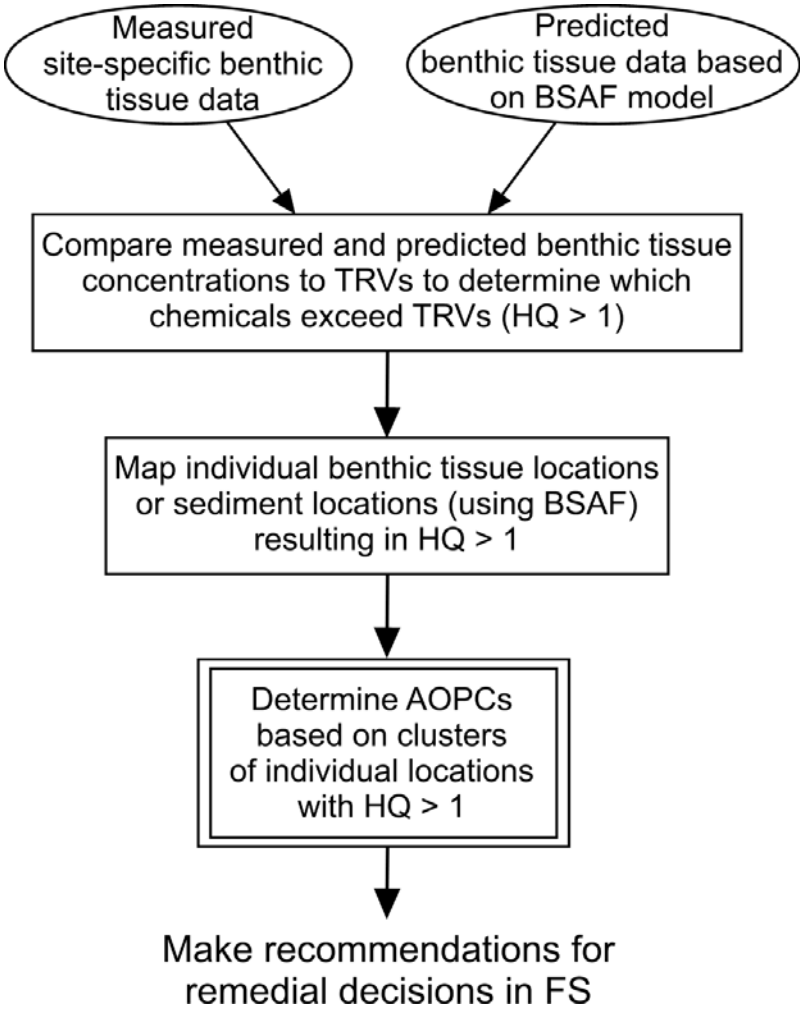

Figure 3. Risk Characterization framework for benthic invertebrates: tissue chemistry LOE

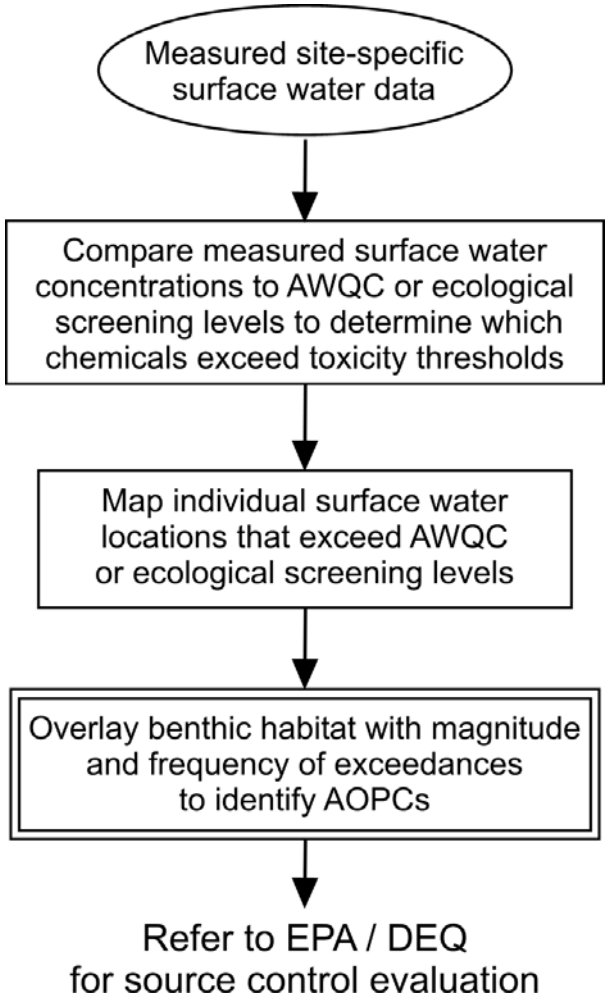

Figure 4. Risk Characterization framework for benthic invertebrates: surface water LOE

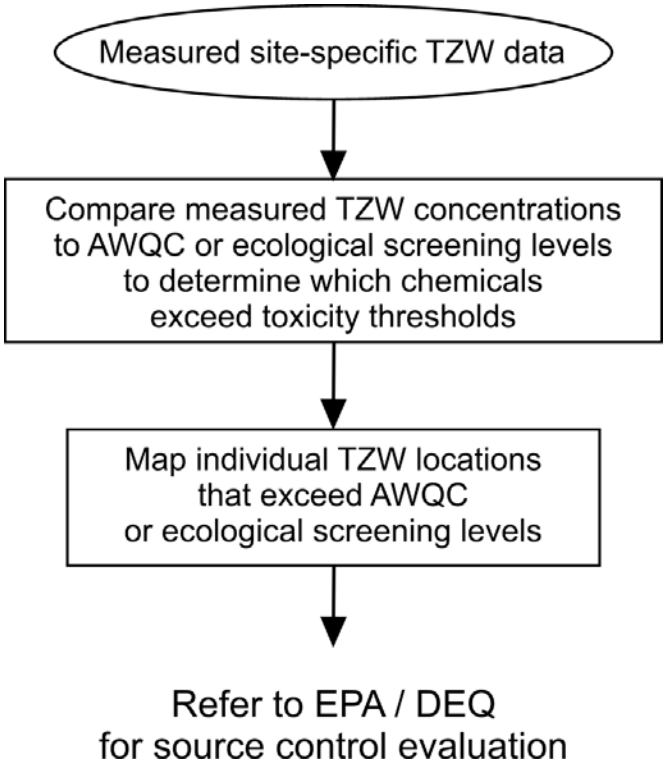

Figure 5. Risk Characterization framework for benthic invertebrates: transition zone water LOE

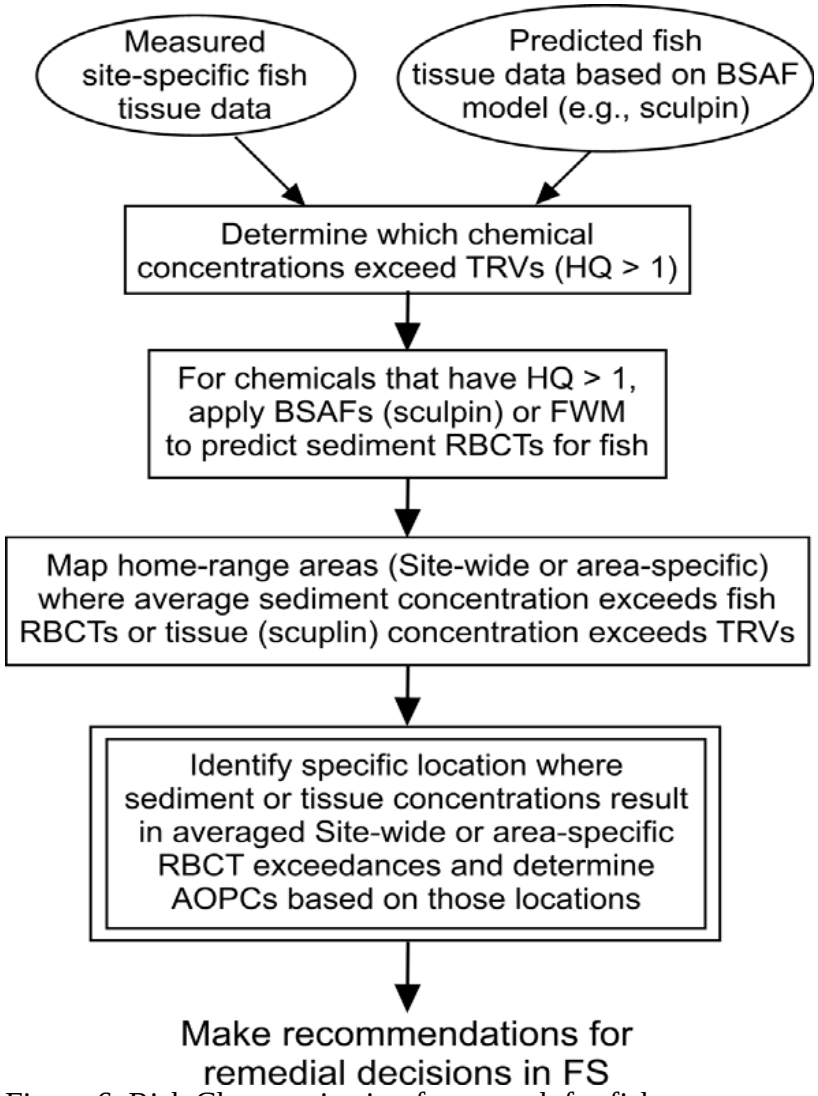

Figure 6. Risk Characterization framework for fish receptors: tissue chemistry LOE

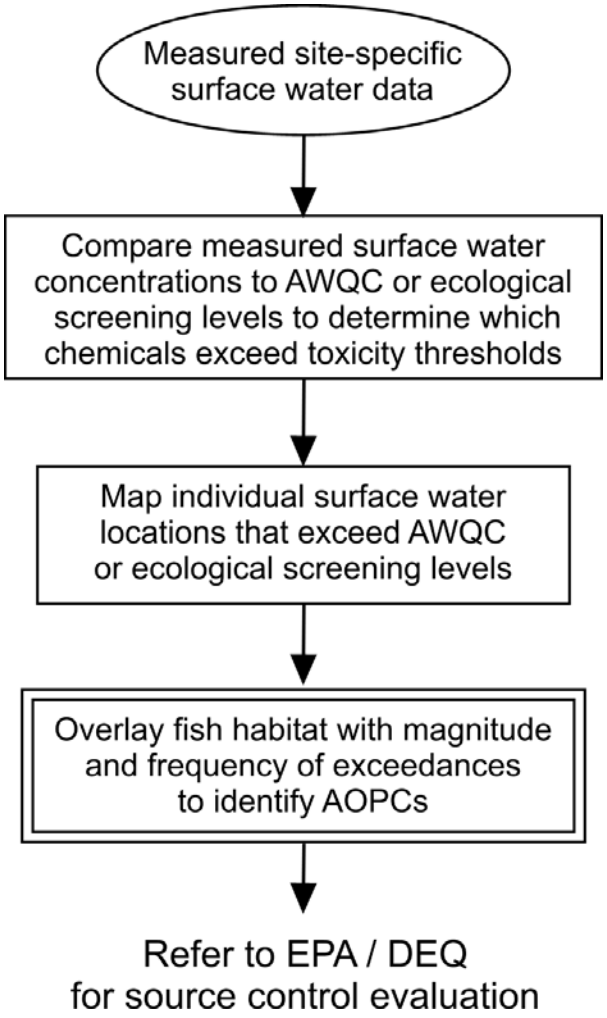

Figure 7. Risk Characterization framework for fish receptors: surface water LOE

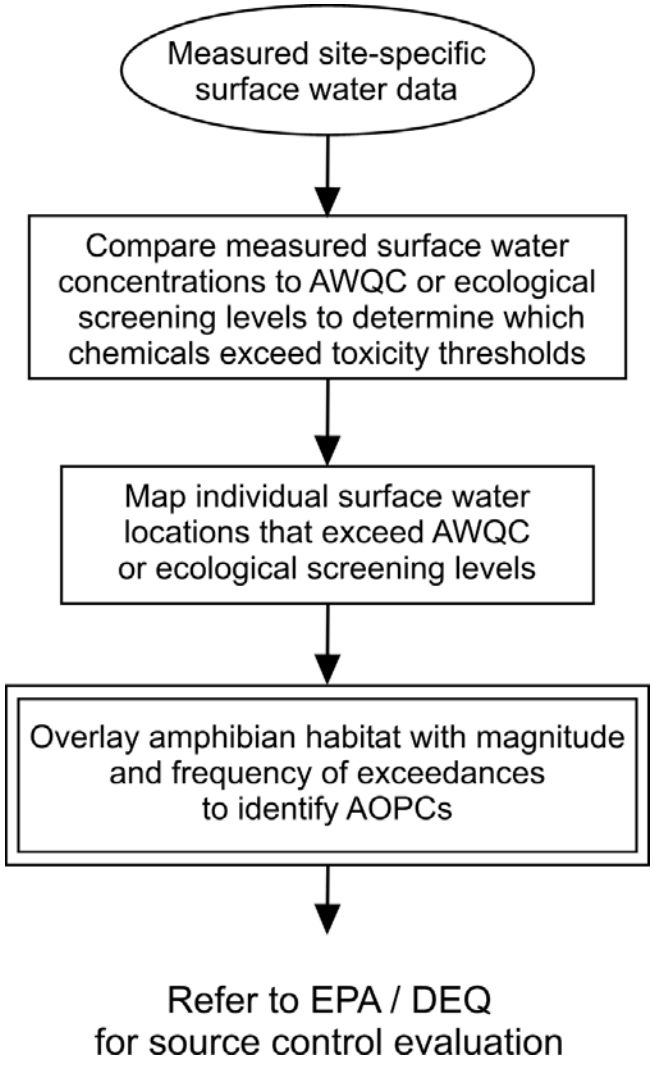

Figure 8. Risk Characterization framework for amphibians: surface water LOE

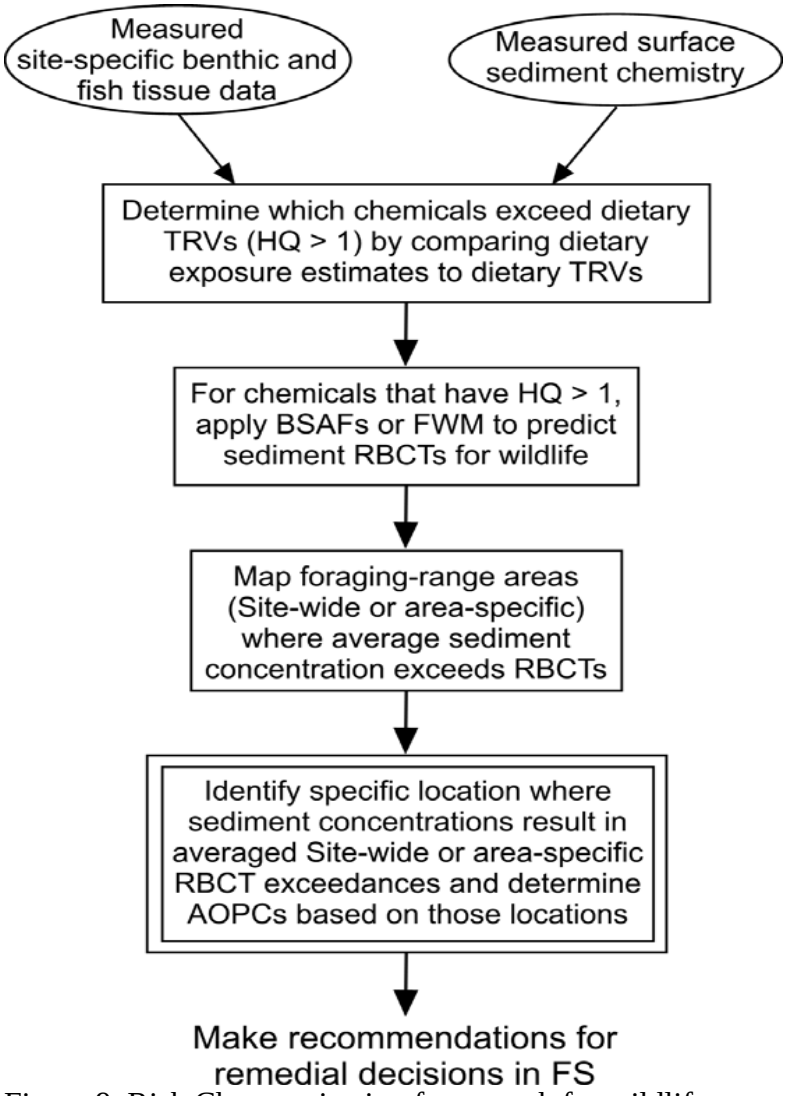

Figure 9. Risk Characterization framework for wildlife receptors: dietary model LOE

6.0 REFERENCES

EPA. 1992. Framework for ecological risk assessment. EPA/630/R-92/001. Risk Assessment Forum, US Environmental Protection Agency, Washington, DC.

EPA. 1997. EPA Region 10 supplemental ecological risk assessment guidance for Superfund. EPA/910/R-97/005. Region 10 Office of Environmental Assessment Risk Evaluation Unit, US Environmental Protection Agency, Seattle, WA.

EPA. 1998. Guidelines for ecological risk assessment. EPA/630/R-95/002 F. Risk Assessment Forum, US Environmental Protection Agency, Washington, DC.

Integral, Windward, Kennedy/Jenks, Anchor, Groundwater Solutions. 2004. Portland Harbor remedial investigation/feasibility study programmatic work plan. Prepared for Lower Willamette Group. Integral Consulting, Inc., Mercer Island, WA; Windward Environmental LLC, Seattle, WA; Kennedy/Jenks Consultants, Portland, OR; Anchor Environmental, LLC, Seattle, WA; Groundwater Solutions, Inc., Portland, OR.

Menzie C, Henning MH, Cura J, Finkelsten K, Gentile J, Maugham J, Mitchell D, Petron S, Potocki B, Svirsky S, Tyler P. 1996. Special report of the Massachusetts Weight-of-Evidence Workgroup: a weight-of-evidence approach for evaluating ecological risks. Hum Ecol Risk Assess 2(2):277-304.

SEA. 2002. Documentation of Risk Assessment Scoping Meeting, December 19, 2001, Portland Harbor Superfund Site, USEPA Docket No: CERCLA-10-2001-0240.

SEA, Windward, Kennedy/Jenks, Anchor, Solutions G. 2002. Portland Harbor remedial investigation/feasibility study: Round 1 work plan. Prepared for Lower Willamette Group. Striplin Environmental Associates, Inc., Mercer Island, WA; Windward Environmental LLC, Seattle, WA; Kennedy/Jenks Consultants, Portland, OR; Anchor Environmental, LLC, Seattle, WA; Groundwater Solutions, Inc., Portland, OR.

Windward. 2004. Portland Harbor Superfund Site ecological risk assessment: comprehensive synopsis of approaches and methods. Draft. Prepared for Lower Willamette Group. Windward Environmental LLC, Seattle, WA.

Windward. 2005a. Portland Harbor RI/FS. Ecological preliminary risk evaluation. WE-05-0007. Draft. Prepared for Lower Willamette Group. Windward Environmental LLC, Seattle, WA.

Windward. 2005b. Portland Harbor RI/FS. Ecological risk assessment: Estimating risks to benthic organisms using sediment toxicity tests. WE-05-0003. Draft. Prepared for Lower Willamette Group. Windward Environmental LLC, Seattle, WA.